New model of municipal solid waste management

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Abstract: In the current scenario, the waste is an indicator of socioeconomic development. So, the more booming economy is, the greater the volume of produced waste. The downside of this scenario is the result of technological bottlenecks of conventional management models. In this context, this paper discusses and proposes a new model for urban solid waste (USW) management, based on the methodology/technology developed at the university. Therefore, the environmental diagnosis and the identification of the advantages/disadvantages of conventional models have been performed, followed up by a new management model based on distinguished methods during the following phases: collection, transport, treatment and final disposal of USW. The results have shown the technical/economical/financial viability of this new technology, in which waste is no longer a cost factor, but an investment opportunity. In this proposal, prevails the economic returns and the impacts on the environment and society are also positive.

Keywords: urban waste; collection; transport; processing; treatment.

Reference to this paper should be made as follows: Morejon, C.F.M., de Lima, J.F., da Rocha, Jr., W.F. and Possa, R.D. (2012) 'New model of municipal solid waste management', *Int. J. Environment and Sustainable Development*, Vol. 11, No. 3, pp.238–248.

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This paper is a revised and expanded version of a paper entitled 'New model of urban solid waste management' presented at the 3rd International Workshop Advances in Cleaner Production, São Paulo, Brazil, 18–20 May 2011.

1 Introduction

At the beginning of this century (XXI), a rainless waste generation is an important issue that affects Brazilian cities due to urbanisation, an increase of population and inadequate management of waste. So, the environmental and public health problems have been highlighted in political, social and economic areas. The generation of waste has been attributed to economic development as well as to the new patterns and people's aptitude of consuming.

Historically, the production of municipal solid wastes (MSWs) has been observed, but in small amounts. In earlier times, they had come mainly from food leftovers, allowing the environment to degrade them in such a way that did not damage natural resources.

From the 19th century, with the Industrial Revolution, this production has begun on large scale. Thus, an increasing number of new products were introduced to the society, causing an important increase in both volume and diversity of waste generated in urban areas (Massukado, 2004).

Despite the impact of industrialisation, the current generation of MSW is also a problem of education, environmental perception and awareness of individuals with different social reactions and attitudes. Therefore, the contemporary model of consumption for waste generation has represented itself more as an anti-social activity than a consequence of the population's consumption needs (Read, 1999; Lima, 2001).

It is known that nature has a limit to absorb the negative impacts that occur on the Planet, therefore, usually; this efficiency has not been enough to absorb all the impacts caused by the waste generation from human activities.

The increase of waste generation requires great demands to the treatment and final disposal, both in amount and characteristics of waste generated (Chadwick and Nilson, 1993; Guerra and Cunha, 2006). According to the National Survey of Basic Sanitation (2000), by the Brazilian Institute of Geography and Statistics (IBGE), there are nearly 126 tons/day of MSW generated in 5,507 Brazilian municipalities. Based on this amount of wastes, almost 47.1% of them are disposed in landfills, 22.3% in controlled landfills and 30.5% in open dumps. But, according to the number of municipalities, the results are less favourable for their final disposal, since 63.6% of municipalities unload their wastes in open dumps, 13.8% in landfills, 18.4% in controlled landfills and 5% of municipalities did not report their waste disposal. Due to this scenario, the lack of treatment and / or correct disposal of several kinds of wastes help to enhance environmental problems that come from increased generation of waste, which can be by the restriction of a conventional technology or by lack of alternative systems (Morejon et al., 2007).

The amount of waste generated by human activity plus the decrease of available places for final disposal have been highlighted as one of the greatest challenges to be solved not only by municipal governments, but also by the whole community that generates it. However, in order to fulfill the environmental, economic and social aspects for each region, it is necessary that companies and municipalities get more efficient on solid waste management, which means: environmentally safe, economically available and socially acceptable.

The treatment of MSW is an important tool on integrated management of solid waste, since it reduces both toxicity and volume of waste required for final disposal in a landfill (Massukado, 2004; Morrissey and Browne, 2004; Verma, 2002). So, many techniques have been proposed to solve these problems: the selective collection, recycling, incineration, pyrolysis, thermal hydrolysis, composting, vermicomposting, anaerobic digestion, encapsulation, drying/dehydration, animals' feeding and disposal in landfill.

However, most of them have restrictions that prevent their use according to Brazilian reality (Souto, 2005). Among these techniques, in Brazil, the most used ones are: landfill, composting and incineration in a lesser extent (IBGE, 2000). Nevertheless, the increase of production and qualitative changes on MSWs associated with the high costs of transaction, management and lack of available areas have made the traditional use of landfills less viable, with a consequent search for more effective economic and environmental alternatives (Picanço, 2004). In addition, when landfills are improperly

designed and operated, they become a potential source of water and air pollution (Souto, 2005).

According to Mata-Alvarez et al., (2000), in developed countries such as the European Community, there are recommendations to reduce the number of landfills due to their negative environmental impact. Capela et al. (2008) point out that, for many years, landfill was the most common form to dispose organic solid wastes.

Nowadays, efforts are essential to develop alternative models for MSW management that should be effective and feasible. In this context, this paper discusses and proposes a new model of MSW management, based on methodology and technology (with a patent application PI 0801312-8) developed by Morejon et al. (2008), which focuses on differentiated stages of collection, transport, use and disposal of solid waste.

2 Methodology

This study shows a methodology that included a diagnosis of the current situation of the environmental impacts caused by MSWs in Brazil, in order to identify advantages and disadvantages of management models widely used, as well as the identification of opportunities that resulted in a new management model based on different methods according to the stages of collection, transport, use and disposal of solid waste.

The proposal of this new management model regarded the technology from the Pro-Nature Clean project and, mainly, the results of case studies in cities of Toledo (PR) and Formosa do Oeste (PR), through partnerships with the Government of Paraná State, State University of Western Paraná (UNIOESTE), Toledo and the city Council of Formosa do Oeste (PR).

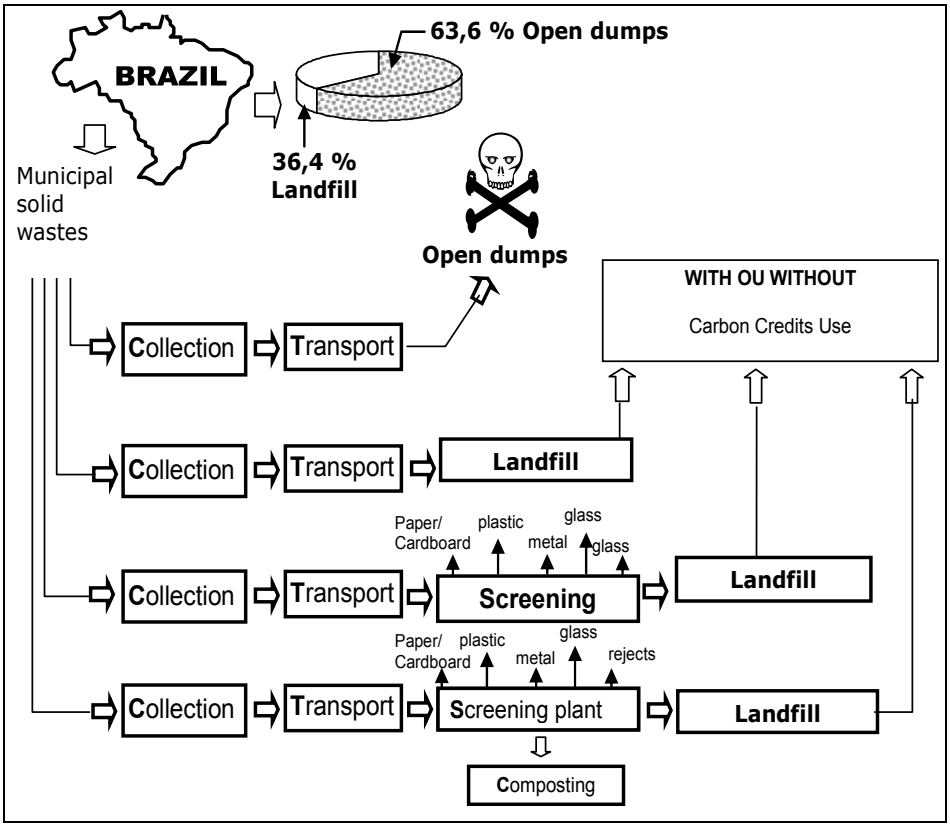
3 Results and discussions

The following results will be presented according to the analysis.

3.1 Diagnosis of the current situation

According to data from the National Survey of Basic Sanitation (PNSB) conducted by IBGE (2000), there was an evaluation based on the amount of waste that was daily collected: in cities with 200.000 inhabitants, from 450 to 700 grams of waste were collected per inhabitant. On the other hand, in cities with more than 200.000 inhabitants, this amount increased from 800 to 1.200 grams per inhabitant. Altogether, 125.28 tons of household wastes were collected in Brazilian municipalities/day. So, from this total, the 13 largest cities account for 31.9% of household waste generated. The current phase of conventional methods of solid waste management from urban activity follows some patterns (Figure 1):

Figure 1 Models for MSW management



The first form of collection (open dumps) is shown in Figure 1 and even though it is not recommended, it is still practiced by most Brazilian municipalities. It collects waste whose final disposal is 'in the open air'. The disposal process of urban waste has negative consequences for the environment, health, social, economic and/or political areas.

A second model consists of waste collection whose final disposal is in landfills. This procedure is not recommended due to the inefficient use of their effective amount, since they receive all kinds of waste, including materials that can be reused. As it is not a minimum screening, all deposited material provides a noticeable reduction in landfill lifetime. New areas of landfills are required, so, the entire municipality has extra-expenses which cause damaging consequences for the city.

The third model is the collection of waste, transport to the plants, partial separation and final disposal of materials that are apparently not usable for landfills. It partially increases their lifetime by reintegrating conventionally recyclable materials in several of human activities.

This kind of methodology is not the most recommended since there is low efficiency of separation/classification in the recycling plant due to the complexity of mixtures (solid wastes extremely contaminated) that interferes on separation and also contributes to unhealthy environments in the screening areas. It also jeopardises environmental agents and population's health as well as the environment. On the other hand, the use through

separation/classification is limited to a few conventional materials and the great part of materials in open dumps does not have the correct appreciation. Other models are a result of combinations of the previous ones, but in all cases, there are technical, economic, social and political restrictions that hamper their applications.

In general, it can be seen that current management models highlight:

a Some concern about the need for separation and recovery of recyclable materials, mainly, aluminum, paper, glass and plastic.

b Concern about the final disposal of waste. In this case, the use of landfills is predominant, with or without the use of gaseous products that come from decomposition/anaerobic digestion.

c That in most models of waste management, the effectiveness is associated to the degree of environmental awareness of individuals.

d That according to the technological point of view, extra innovation, based on the conventional methods and technologies are widely used.

e There is still a scenario of dissatisfaction concerning the environmental issues and their negative consequences.

3.2 Proposal of a new management model

As it was shown, the conventional processes and technologies are always under analyses and study, since these methodologies and technologies have not met the expectations of solving such problem that comes from an inadequate management of urban waste.

The researchers have shown that the problem of solid waste management is focused on the organic one, because when it is mixed with a dry waste (mostly recycled), it hinders and makes difficult their reuse. However, in today's management models, little or no attention is given to organic waste. On the other hand, a research developed at the State University of Western Paraná (UNIOESTE) in *Campus* of Toledo city has shown that the organic waste has a great potential for adding value and when it is processed according to an industrial enterprise, its economic expectations are above average.

This technology comes from a research that was carried out in the Formosa do Oeste city by UNIOESTE and financed by Paraná State Government. The result was an innovative methodology and technology (UNIOESTE model) in order to manage household waste (patent PI-0801312-8 from April, 10th, 2008).

This new methodology/technology proposes a new form of collection, transport, use, processing and industrialisation of urban household waste. After proving technical and economic innovation in laboratory scale, it was important to carry out the second phase of this project, through an implementation, under pilot-scale, of a plant to industrialise household organic waste. After this phase completion, it will be possible to transfer an optimised method/technology and its corresponding deployment in a real situation. Thus, this technological extension will change an environmental problem into a source of opportunities for sustainable regional development.

So, the proposal of this new management model would be focused on organic waste, which must be separated and collected at its source (households). This challenge would be achieved by assigning an economic value to this kind of waste. Since it is a raw

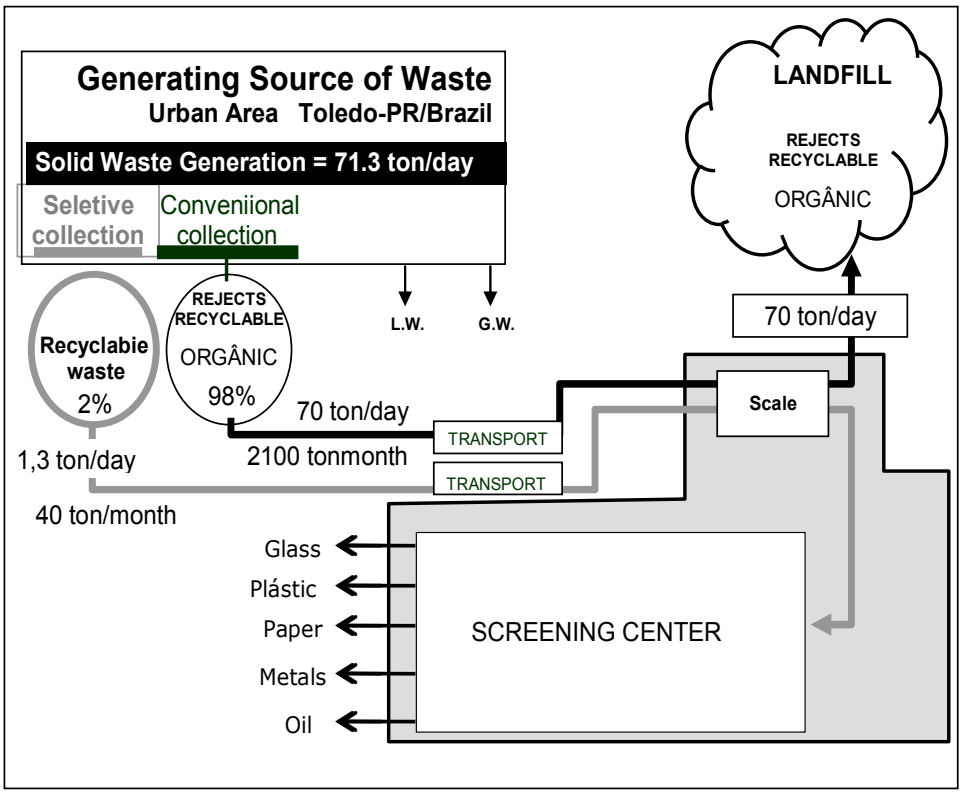
material of an industrialisation process, there is an expectation of an economic feedback, so, it would be possible such economic repayment according to the amount that was collected and separated at source. Therefore, the economic incentive is highlighted when compared to an environmental awareness and/or law enforcement.

3.3 Case study

In order to highlight such proposal, it was considered the case of Toledo city with 115,000 inhabitants, which has a landfill and a screening centre and its population is pleased with this system of solid waste management.

This trial was developed by Morejon et al. (2008) and it is briefly outlined in Figure 2. The researchers observed that this city collects an average of 71.3 tons of MSW a day. Nowadays, from this amount, only 2% (1.3 ton/day) corresponds to the selective collection and 98% (70 ton/day) of the waste have the municipal landfill as final destination.

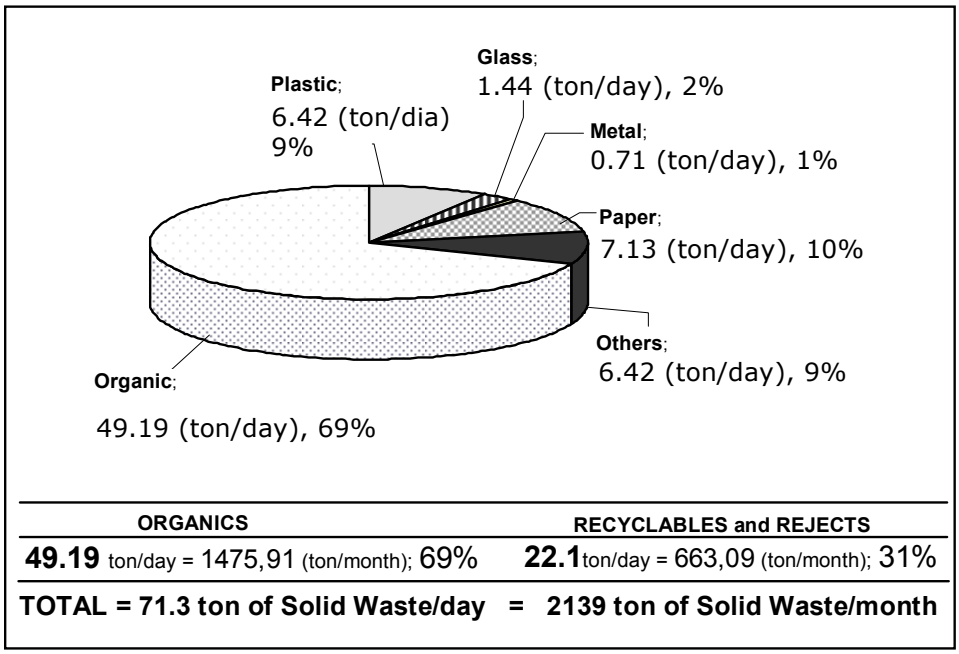
Figure 2 Results of current model of MSWs management in Toledo City in Brazil (2010) (see online version for colours)



This research developed in Toledo city has pointed out what kind of waste is produced there, which is not so different from the reality of other Brazilian cities. The result is shown in Figure 3 and fractions of urban waste components are specified. In this graph, it

can be observed that organic waste represents 69% (49.19 ton/day) of the total and the remaining amount, 31% (22.1 ton/day), is distributed among the recyclable ones (16.4 ton/day, 23% of total) and the rejected part (5.7 ton/day 8% of total).

Figure 3 Characteristics of solid wastes produced in the Toledo city in Brazil (2010)

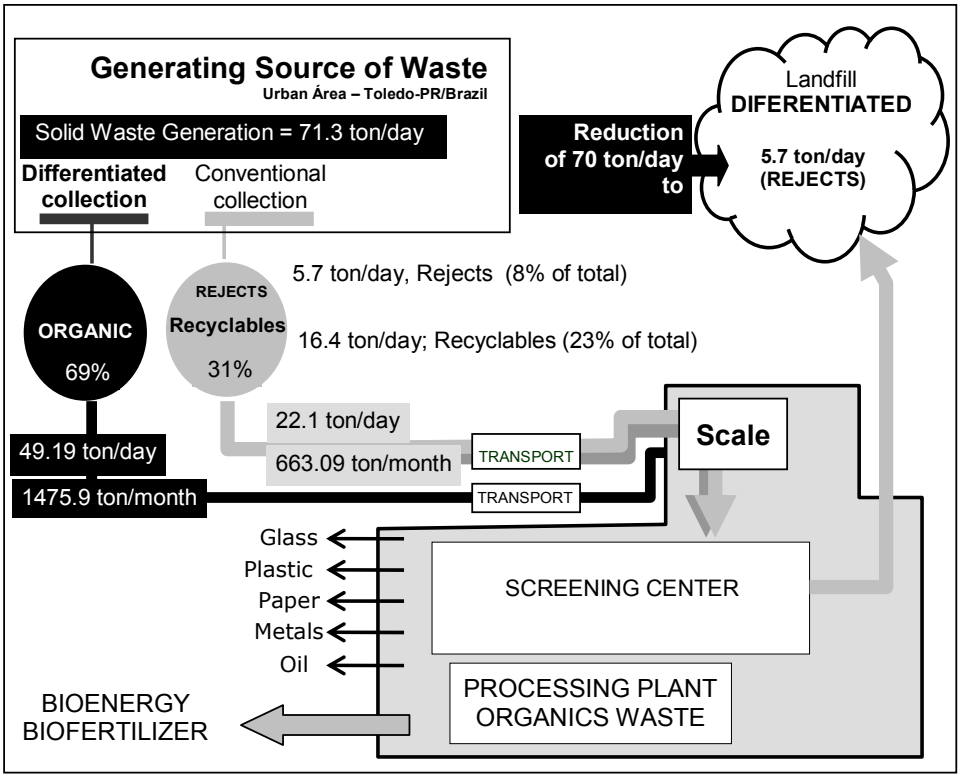


This proposal, based on the methodology and technology from Pro-Clean Nature project, socialises the implementation of mechanisms and management models that provide more attention to organic waste, because it shows the biggest environmental problems, but, at the same time, it can have the greatest opportunities to solve problems that come from inadequate management of municipal waste. So, according to Figure 4, the challenge of separation and collection of organic waste at source, obtained by assigning an economic value as a method of incentive, would be complemented with the implementation of processing plants of organic wastes.

The results of such processing would be the production of: biogas, derivatives (electricity, thermal energy, etc.), bio fertilisers and carbon credits. All of them have a right destination for the markets and attractive economic expectations. The remaining part of waste (dry and recyclable waste) would be collected and transported to the screening centres, even if they are mixed. Thus, the recyclable ones (16.4 ton/day, 23.5% of total), as they are free of organics, enable screening processes, in a less unhealthy environment and, especially, a more efficient reuse. On the other hand, the waste (5.7 ton/day; 8% of total) would be disposed in a landfill that is different from the conventional one.

According to this model, for Toledo City in Brazil, from 70 ton/day of waste currently disposed in a landfill, it would receive only 5.7 ton/day of waste. This represents a 91.8% reduction in the amount of received waste.

Figure 4 Proposal of new model of urban solid waste management



On the other hand, the differentiated collection, transport, processing and marketing of value-added products both organic waste and recyclable ones contribute for the generation of jobs, income and especially for a sustainable environment.

Specifically, the technological product, inherent to an optimised management of MSW, named as "modular system of collection, transportation and industrialization of household solid waste", patent application PI 0801312-8, refers to a system that allows the industrialisation of household solid waste activities from urban and/or rural area.

It includes a differentiated method for collecting solid waste from household activities, as well as differentiated methods for transporting solid waste that was previously collected, a differentiated method/technology for processing organic solid waste and a differentiated method for processing gaseous products that result from organic solid waste processing; a differentiated method for solid material processing that results from solid organic waste processing and the presentation of alternative application/use of solids, liquids and gaseous products from these processes. There are also alternatives to use other materials that make part of solid wastes from household activities, including the recyclable ones.

The system has received implementation/installation/construction/operation in order to improve efficiency and reduce costs of: implementation, construction, installation, operation and reduce space for installation. As a result, this system had a versatile application that allows wastes to be changed into value-added products which, under real situation, it may not need conventional landfills.

4 Conclusions

The concern about waste separation and the use of recyclable materials have predominated on current models. Thus, little or no attention is given to organic waste, which represents 69% of household waste. In relation to the final destination of waste, this research has shown that there is a stimulus to use landfills. However, current practices have been impairing soil quality as well as interfered on finding appropriate areas, the significant increase on waste amount and, especially, the negative consequences of chemical, physical and biological changes of waste (in the landfill), consequently, they have inferred that those are not the right decision-making. The effectiveness of conventional management models is associated to the individuals' level regarding environmental. Based on the technological point of view, some incremental innovations that are incorporated to the conventional technologies have reached the improvement limit. Thus, a radical innovation is essential that meets all expectations in a positive way. According to such need, a new management model was shown, based on a technology developed by a group of researchers from Unioeste, whose main component is to give greater attention to organic waste. The implementation of this new model proposes differentiated methods and technologies in the following phases: collection, transport, treatment and final disposal of MSW. Based on the case studies, the results have shown that there is a technical and economic availability of this proposal. And waste is no longer a cost factor, since it becomes an investment opportunity. In this proposal, the economic variable is the best attraction for individuals and, at the same time, the impacts on the environment and society are also positive. So, this study aims at changing an environmental problem into a source of opportunities for new business models, in which waste is regarded as raw material of industrial processes.

Acknowledgements

The authors would like to thank the Brazilian National Council of Scientific Research (CNPq), Araucaria Foundation, as well as Formosa do Oeste and Toledo Cities Council's.

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